Modeling Land Cover Change to Understand Conservation Outcomes in Coastal California

Abstract

Urban expansion in diverse ecosystems has numerous detrimental impacts, including diminished biodiversity, impaired water quality, and reduced carbon storage potential. In the Carmel Valley region of California's Central Coast, the Santa Lucia Preserve (SLP) implemented a unique land management plan in the 1990s to allow limited development while conserving the majority of the land. Our goal was to test whether our partner's (Santa Lucia Conservancy) management plan reduced urban spread and forest cover loss compared to surrounding areas from 1991 to 2019. We used Landsat 5's Thematic Mapper and Landsat 8's Operational Land Imager (OLI) to classify land cover into eight classes (agriculture, developed [infrastructure], developed [structures], forest, grasslands, rocks/cliffs, shrubs, water) using a random forest classification in R Studio, then modeled land cover change using IDRISI TerrSet Land Change Modeler (LCM). The best models for both years used all variables and a combined developed class (1991 OOB error = 17.4%, 2019 OOB error = 20.1%). The greatest vegetation loss occurred in grasslands; 11% of grasslands on SLP became developed, along with 14% of public and 12% of private. Throughout the study area, developed and forest land cover increased by 2%, while grasslands decreased by 4% and shrubs by 2%. Approximately 3.5% of privately owned forest was developed, while about 1% of public and SLC-owned forests were. The transition between vegetation classes masked losses within each class, and further analysis of the drivers of land cover change is necessary to fully evaluate the efficacy of the SLC conservation model.

Objectives

- **Analyze** change in vegetation cover in and around Santa Lucia Preserve from 1991 to 2019
- **Produce** land cover change maps of neighboring properties to the Santa Lucia Conservancy
- **Compare** land cover changes and development rates under various conservation models

Methodology

Input parameter preparation

- Extract spring, summer, fall imagery
- 1991, 2019 Landsat
- Calculate indices
- TCW, TCB, TCG, NDMI, NDVI
- Generate training points
- Spread throughout SLP and entire study area
- ~250 per class
- Calculate topographic variables
- Slope, landform, aspect, roughness, surface relief ratio, distance to road, soil

Modeling and classification

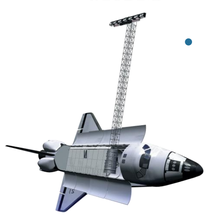
- Stack rasters, extract training points
- Run random forest models
- Predict land cover classifications

Land change analysis

- Model land cover change in IDRISI TerrSet

Earth Observations

SRTM

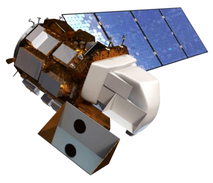


- Digital elevation model

Landsat 5 TM

- Satellite and spectral data for 1991 (left) and 2019 (right)

Landsat 8 OLI



Team Members

Cooper Campbell
Project Lead

Devina Garcia

Julia Portmann

Audrey Wilson

Study Area

Santa Lucia Preserve (SLP):
A conservation community

- ***Wildlands*** (no development) – 10,000 acres
- ***Openlands*** (privately conserved) – 8,000 acres
- ***Homelands*** (private development) –2,000 acres
- Surrounding region has faced high urbanization, which reduces biodiversity, habitats, and ecosystem services.

Figure 1. Map visualizing the overall study area, with the SLP outlined in white (Left). Images of the SLP were provided by the SLP (Middle, Right).

Results

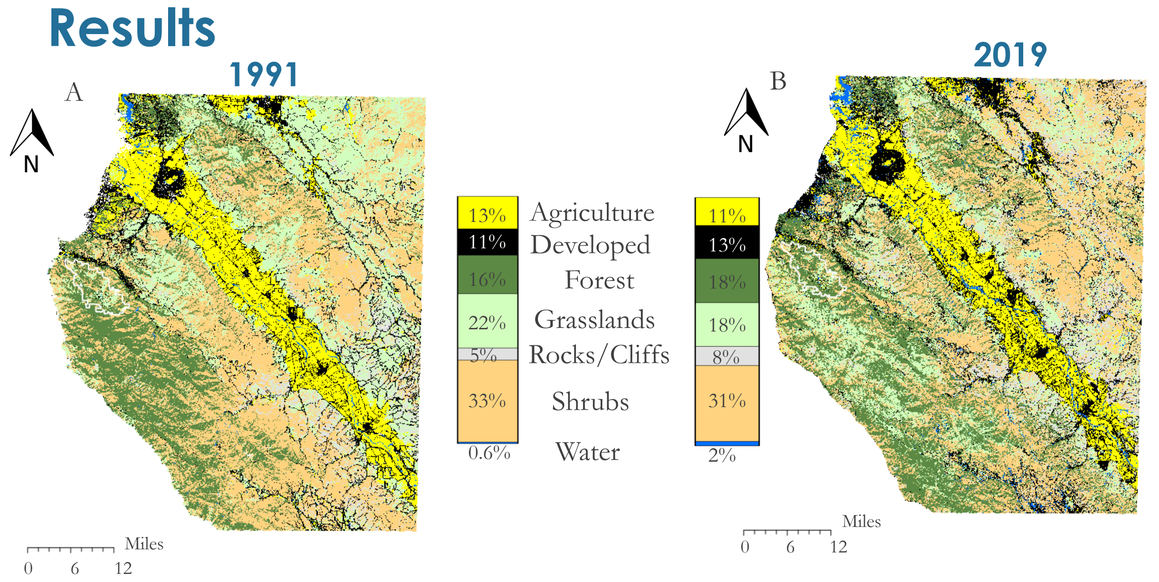


Figure 2. Final land cover classification for 1991 (A) and 2019 (B) using all input variables.

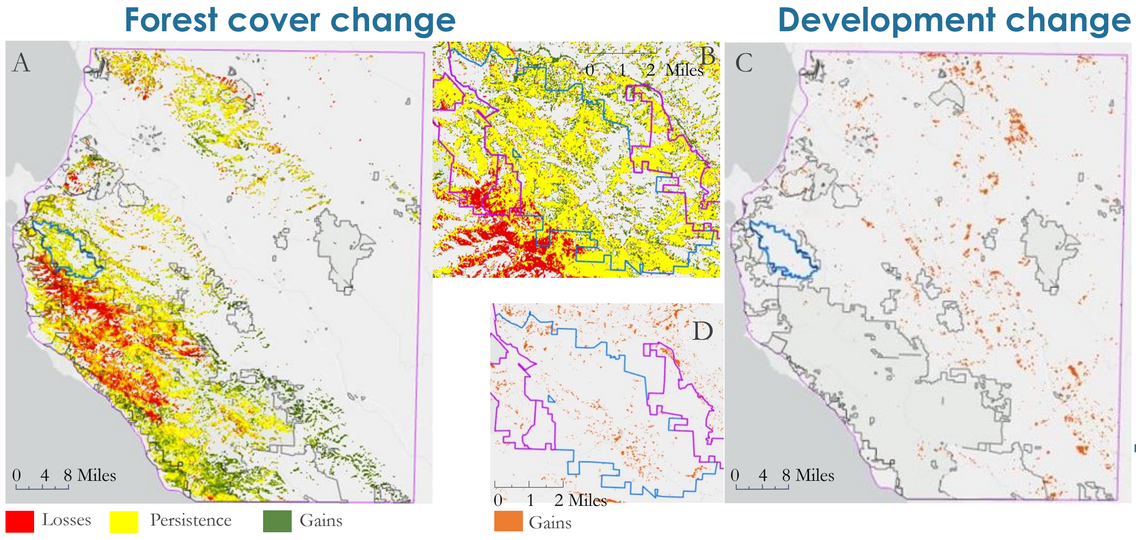


Figure 3. A & B shows forest cover change in the study area (A) and on the SLP (B). The wide expanse of forest loss in the western region was primarily due to the 2016 Soberanes fire. C & D show increases in development in the study area (C) and the SLP (D). Neighboring conserved properties are outlined in gray or purple.

Conclusions

- Due to historic underestimation of their importance, grasslands experienced the greatest conversion to developed or agricultural land.
- The SLC experienced the smallest conversion of grassland to other cover types and a large increase in forest.
- Modeling land cover in an intermediate year and utilizing disturbance modelers could identify areas of concern and drivers of land changes.

Acknowledgements

- Sarah Hettema - DEVELOP Fellow
- Dr. Tony Vorster - Science Advisor
- Dr. Brian Woodward - Science Advisor & Partner

Project Partner

Santa Lucia Conservancy

Carmel Valley Urban Development

This material is based upon work supported by NASA through contract NNL16AA05C. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.